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# SEASONAL HISTORY AND OCCURRENCE OF *FIORINIA EXTERNA* FERRIS IN PENNSYLVANIA (HOMOPTERA: DIASPIDIDAE)

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*Abstract.*—The life history and occurrence of the elongate hemlock scale, *Fiorinia externa* Ferris, was examined on *Tsuga canadensis* (L.) Carr. from 1977–78 in Pennsylvania. In southeastern Pennsylvania the scale had multiple overlapping generations, with adult females, eggs, settled crawlers, and second instars of both sexes overwintering. Crawlers were most abundant in May and June. It was found in nine (mainly southeastern) counties of Pennsylvania. Other hosts were *Tsuga caroliniana* Engelm., *Abies balsamea* (L.) Mill., and *Abies fraseri* (Pursh) Poir.

Ferris (1942) described the armored scale insect *Fiorinia externa* from material collected in Baltimore, Maryland in 1942. However, he stated that this scale was probably introduced from the Orient and was the same species that Sasscer (1912) had misidentified as *F. fioriniae japonica* Kuwana from Long Island, New York. Ferris also stated that *externa* could have been previously described as *F. multipora* Lindinger from *Taxus* in India, but it was unrecognizable because of Lindinger's vague description. Since Ferris' work, several authors have reported on the life history and severity of this pest in the eastern states. It has been recorded from Maryland (Garrett and Langford, 1969); Westbury, New York (Duda, 1957); Marion, Massachusetts (Bray, 1958); Connecticut, New Jersey, Ohio, and Pennsylvania (Davidson and McComb, 1958); Virginia (Talerico et al., 1967); and Rhode Island (Baker, 1972).

*Fiorinia externa*, the elongate hemlock scale, is now a serious pest of ornamental hemlock in southeastern Pennsylvania, found most often infesting large, mature trees in parks, cemeteries, along streets and roads, and in established home plantings. It is seldom found in nurseries where spray schedules are maintained. Because of the large size of the trees most commonly infested, control is expensive, and complete spray coverage is nearly impossible for homeowners to obtain. Life histories of *F. externa* in states

surrounding Pennsylvania have been well documented. McClure (1977a, b, 1978a) reported a summer and incomplete autumn generation at Westport, Conn. McClure and Fergione (1977) dealt with distribution, abundance, and hosts of *F. externa* in southwest Connecticut. Bray (1958) noted that the scale has 2 generations per year in Massachusetts. Davidson and McComb (1958) and Garrett and Langford (1969) reported multiple generations in Maryland. With these differing reports from surrounding states, and the fact that chemical controls applied at recommended times are often ineffective, I initiated a life history study of this insect in Pennsylvania.

## Methods

Seasonal history data were compiled by analyzing weekly samples collected during 1977–78 from Pennsbury Manor, near Tullytown, Bucks County, Pennsylvania. Each sample consisted of several 15–20 cm twigs of Canadian hemlock, *Tsuga canadensis* (L.) Carr., which were infested with *F. externa*. During the coldest months (November through March) samples were taken only once a month. Samples were examined under a dissecting microscope, and the first 100 living forms encountered (from terminal to base) were sorted to stage. A sample size larger than 100 individuals would have presented more accurate data (i.e., eliminated "holes" in the graph in Fig. 1), but time did not permit this. Data on exact duration of various stages were not obtainable with this procedure; thus, the figures given for length of stadia are only approximate. The stage of most individuals could be determined by examination under the dissecting microscope; those that could not were mounted in Hoyer's medium on microscope slides and examined under phase-contrast. Eggs were counted as living individuals. Stages were determined by the following criteria:

Eggs.

Active crawlers (not sorted to sex).—Freely moving, wingless, not attached to host by stylets.

Settled crawlers.—Only slightly larger than active crawlers, attached to host by stylets, antennae and legs visible, scale cover beginning to form.

Second-instar females.—Elongate, attached to host by stylets, adult-like with pygidium, no legs or antennae, no darkened eyespots.

Second-instar males.—Elongate, attached to host, margin of pygidium much more jagged and irregular than that of female, no legs or antennae, eyespot areas darkened and visible (in mature specimens of the second instar), scale covering more white, loose, and woolly than that of female.

Adult females.—Have eggs or perivulvar pores and/or are shrunken into second instar exuviae ("pupillarial" form), attached to host by stylets.

Prepupal males.—Not attached to host by stylets, body plainly segmented, vestiges of appendages becoming visible, eyespots visible.

Pupal males.—Appendages becoming well developed, eyes well developed and plainly visible, not attached to host by stylets.

Adult males.—Active, legged, winged, non-feeding.

The distribution survey was carried out by nursery inspectors for the Pennsylvania Department of Agriculture, and the author. Inspectors watched for infested hemlocks during their routine inspections, as well as in roadside and private landscape plantings. When an infestation was found, they collected and sent a sample to the laboratory in Harrisburg for positive identification. Forest trees were rarely observed, and absolute densities were not determined. All counties in the state were surveyed.

## Seasonal History
## Fig. 1

In Pennsylvania *Fiorinia externa* had overlapping stages, which could indicate either an unsynchronized single generation, or multiple overlapping generations. It overwintered as eggs, settled crawlers, second instar males and females, and adult females. Upon the arrival of warm weather, development of these stages continued. Active crawlers appeared April 5 in 1977, the earliest date of emergence in the 2-year study. As these crawlers settled and developed, overwintering second instar females matured early in the season, and there was a nearly constant maturation of adult females, which led to a continuous production of eggs. There were no precise, synchronized generations as would be seen with a scale that overwinters in just one form. Crawlers were most abundant during May and June, and they preferred to settle and feed on the newest growth available.

Greatest continuous egg production occurred from late April through late May, when eggs composed over 75% of the samples. If this period of peak egg production is followed through the succeeding developmental stages (Fig. 1), it appears that adults of this generation matured from mid-to late July, an approximate developmental time of 3 months. While this seemed long, late April and early May remained relatively cold during the study. I suspect that eggs produced in June or July hatched and matured in a shorter time than did those of April. Adult females remained alive for some time after oviposition, as samples contained numerous living females whose covers were filled with empty chorions and no eggs. Production of young continued throughout the summer, and those forms aforementioned in this section were found to be viable in the winter samples.

In processing the weekly samples, I observed that each female bearing eggs held an average of 6 unhatched eggs under her covering. However, total fecundity was higher, as indicated by the number of chorions contained under the females' armor. This agrees with Davidson and McComb's (1958) findings, who determined (through chorion counts) that the average fecun-

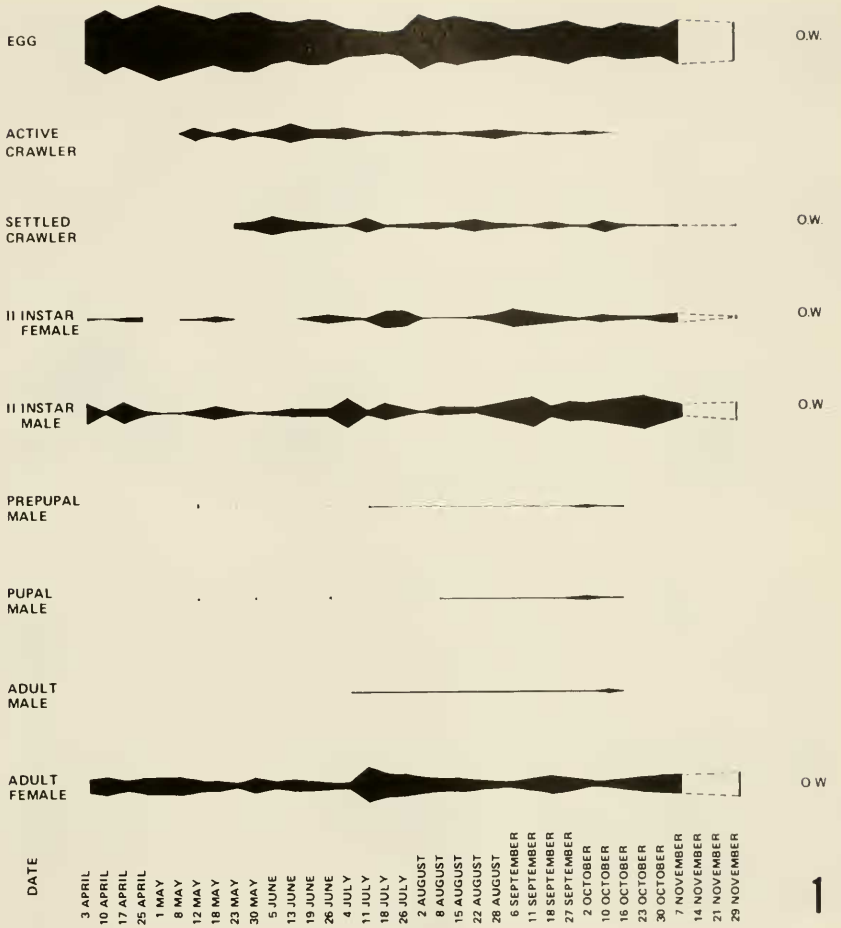


Fig. 1. Seasonal history of *Fiorinia externa* in 1978. (Dotted lines in November indicate data extrapolated for weeks when samples were not taken; o.w. = overwinters.)

dity was 20.4. Observations I made on crawler activity and the adults' behavior during oviposition agreed with those of Davidson and McComb (1958).

Natural enemies were not reared from the samples. Specimens submitted for the seasonal history study contained few parasites. However, an occasional sample submitted in the distribution survey showed evidence of heavy parasitism from blackened scales and empty scale coverings containing parasite emergence holes. McClure (1978b) elaborated on the potential of 2 eulophid parasite species for control of *F. externa*.

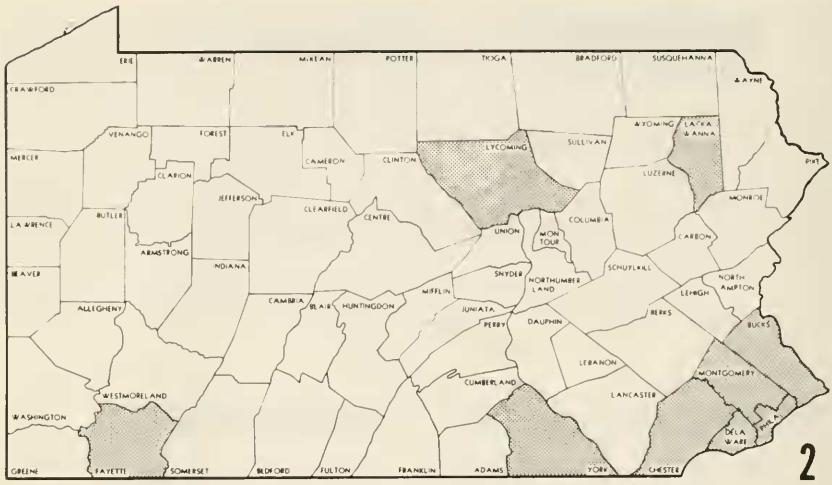


Fig. 2. Occurrence of *Fiorinia externa* in Pennsylvania.

## Hosts and Occurrence in Pennsylvania

*Fiorinia externa* was taken in 9 Pennsylvania counties: Bucks, Chester, Delaware, Fayette, Lackawanna, Lycoming, Montgomery, Philadelphia, and York (Fig. 2). The largest populations were found in southeastern Pennsylvania. The isolated populations found in northern and western counties were not as large (less dense, fewer males) as those in the southeast.

Although the majority of samples came from the scale's principal host, Canadian hemlock, *F. externa* also was collected from Carolina hemlock, *Tsuga caroliniana* Engelm.; balsam fir, *Abies balsamea* (L.) Mill.; and Fraser fir, *Abies fraseri* (Pursh) Poir. An extensive host list has been prepared by McClure and Fergione (1977) for *F. externa* in Connecticut.

## Damage

*Fiorinia externa*, according to Talerico et al. (1967), injures its host by removing plant fluids through the insect's stylets, although Wallner (1978) explains that digestive enzymes may be released into the tissue and damage the host. *F. externa* fed only on the leaves and was always found on the undersides of the needles. Usually the upper leaf surface bore a chlorotic area in the immediate vicinity of stylet penetration. Extended periods of feeding caused premature needle drop, and high populations caused leaf loss sufficient to kill limbs and sometimes entire trees. Infested trees had a sparse, unthrifty appearance because of the needle drop, and the chlorosis on the leaves lent a pallid color to the tree. In addition, the buildup of the white male scale coverings gave the trees a whitewashed appearance.

In southeast Pennsylvania infestations of *Fiorinia externa* were often ac-

companied by populations of another introduced insect, the so-called hemlock woolly adelgid, *Adelges tsugae* Annand. This adelgid had the ability to reach high population levels and render trees unsightly from copious secretions of filamentous white wax.

## Discussion

In Pennsylvania eggs hatch and crawlers emerge over the entire summer, and this is probably the reason why *Fiorinia externa* is so difficult to control. Workers who follow present written recommendations and apply crawler sprays only in June and August do not kill crawlers which emerge at other periods of the season. The adult females and their eggs are protected from most contact insecticides because of their pupillarial conformation (adults are enclosed within the second instars' exuviae). Thus, many ovipositing females sprayed in June are not killed, and continue to produce eggs and crawlers until their natural death. Resulting crawlers have sufficient time to settle and produce protective coverings before the next scheduled spray (August). Probably the best (though somewhat impractical) suggestion for control is spraying at 7–10 day intervals throughout the summer. These applications would be aimed at killing all early instars before they have a chance to settle and produce protective coverings. In nurseries where strict spray schedules are followed, *F. externa* does not become a problem.

## Acknowledgments

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